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AUTHOR	Doyle, Michael P.
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ABSTRACT

Using grant and publication data from nearly 3,000 faculty members in the natural sciences at 133 predominantly undergraduate universities, this study investigated the characteristics of faculty who received $1,000,000 or more in external grant support during the 1990s. This selection required the faculty member to receive $100,000 annually through 10 years. As is consistent with Zipf's Law, (G. K. Zipf; the probability of an item starts high and then tapers off; a few occur very often, while others occur rarely) only about 51 of the 2,980 natural sciences faculty responding (1.7%) received these high grant amounts. The paper reports the relevant characteristics of rank, gender, and discipline for the high grant recipients. However, these million-dollar faculty do not provide a clear pattern of drawing students into science. A study of faculty members with 30 peer-reviewed publications, only 38 of 2,980, shows that these faculty also do not demonstrate a clear advantage in drawing students into science. Overall findings show that is the rare faculty member who chooses to conduct a significant research program that involves undergraduate students in meaningful ways. (SLD)

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Zipf's Law Revealed at Predominately Undergraduate Institutions: Million-Dollar and Thirty-Publication Faculty

Research Corporation

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1

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Research Corporation SPECIAL REPORT DECEMBER 2001

ACADEMIC EXCELLENCE

A study of the role of research in the natural sciences at undergraduate institutions

Zipf's Law Revealed at Predominantly Undergraduate Institutions: Million-Dollar and Thirty-Publication Faculty

The amplification of positive deviants, as Harvard professor and Nobel laureate Dudley Herschbach reported ("Understanding the Outstanding: Zipf's Law and Positive Deviants," *The SourceBook*, pp. 70–74), is a desirable strategy. "It emphasizes," he says, "the key role of 'outliers,' whose example can empower a community or institution to achieve performance well beyond presumed limitations." But who are these "outliers" whose activities allow them to stand out as exceptional? Having grant and publication data from nearly 3,000 faculty in the natural sciences at 133 predominantly undergraduate colleges and universities, we set out to identify the characteristics of faculty who received $1,000,000 or more in external grant support during the 1990s. This selection required that the faculty member received $100,000 annually through ten years, which is, however, only about four times the average amount of research support per faculty member per year reported in *The SourceBook* (Table 5.2). Who are they? From where do they come? How are they supported? What is their involvement with undergraduate students?

Consistent with Zipf's Law, the number of faculty receiving $1,000,000 or more in total external grant support is only fifty-one out of the 2,980 natural sciences faculty responding (1.7%).* Twenty-three are at 17, mainly (15/17) bachelors-degree granting, private institutions (out of 104 total), and twenty-eight are at 11, mainly (9/11) advanced-degree granting, public institutions (out of 32 total). Thirty-four of these million-dollar faculty (67%) are at only 11 of the 133 responding institutions (8%), and nine are in departments that offer the Ph.D. degree. One institution reported seven faculty who had $1,000,000 or more over 10 years; another reported five. Seventeen institutions reported one each of the million-dollar faculty members. Relevant characteristics of rank, gender, and discipline are in Table 1.

*Those who responded were two-thirds of the total number of faculty at the surveyed institutions.

External Grants

A word of explanation is in order here. What is meant by external grants? In *The SourceBook* we define this accounting as "traditional faculty-driven external proposals." Examples include NSF-RUI grants, but not NSF-REU grants, NSF-CAREER Awards, but not NSF-MRI grants, NIH-R01 and NIH-AREA grants, but not group NIH-MBRS grants. Grants awarded to departmental units or to larger entities, such as HHMI awards and NSF-ILI grants, are not included in the compilation of individual faculty awards. The distinction made is not related to who wrote the grant proposal, but how it is considered by reviewers and the funding agencies in making an award. For example, a NSF-ILI proposal is judged primarily for the educational impact in academic departments rather than

Table 1. Rank, gender and discipline characteristics of the 51 million-dollar faculty.

RANK	
Assistant Professor	3
Associate Professor	9
Full Professor	39
GENDER	
Female	9
Male	42
DISCIPLINE	
Biology	20
Chemistry	8
Geoscience	5
Physics	14
Environmental Science	3
Neuroscience	1

on the professional development of the "principal investigator," and often the designated contact is not the person who wrote the proposal. On the other hand, review of a NSF-RUI or NIH-AREA proposal is based primarily on the proposed activity and the ability of the "principal investigator" to accomplish what is proposed.

Individual total external funding ranged from $4.26 million to $1.03 million with the median at $1.4 million. The average number of grants per faculty member was 18 with a range of 2 to 126. Twenty-five faculty had 10 or more grants during the 1990s. By far the greatest source of funding for the million-dollar faculty was the National Science Foundation, which was the major contributor to twelve of them. Few faculty had a single source of funding, but for thirty-three of them one national source contributed more than two-thirds of their total funding:

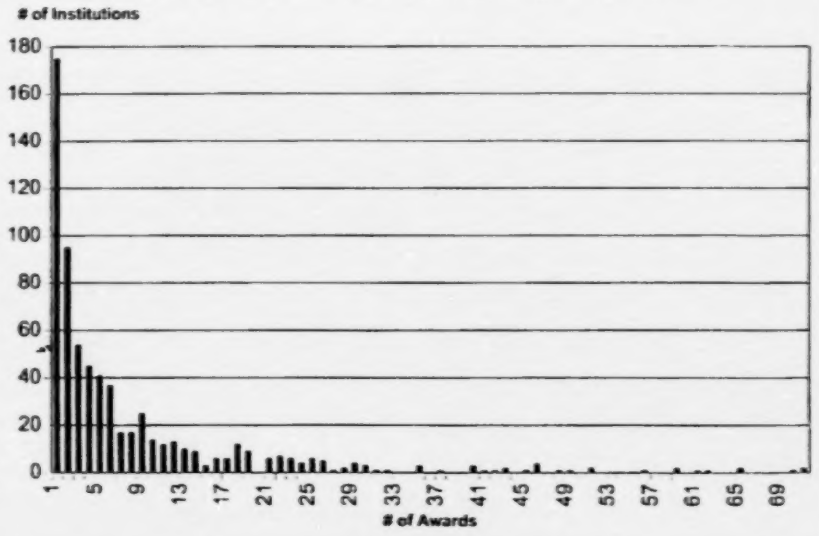
National Science Foundation (NSF)	12
National Aeronautics and Space Administration(NASA)	7
National Institutes of Health (NIH)	6
Department of Energy (DOE)	2
Environmental Protection Agency (EPA)	2
Office of Naval Research (ONR)	2
American Heart Association	1
National Park Service	1

Those funded mainly by the NSF were five physicists, five chemists, and two geoscientists, ten of whom ranked at the full professor level with two as associate professors. NASA funded three physicists, two environmental scientists, one chemist, and one geoscientist, all at the full professor level. The NIH provided major funding for three biologists, two chemists, and one neuroscientist, four of whom were full professors, but one each at the associate and assistant professor levels. Thirteen faculty received their million-dollar support from a combination of sources, most of which included significant grants from the National Science Foundation: NIH/NSF (3), NSF/private foundations (2), ONR/NSF (2), NASA/NSF/DOE (2), ONR/AFOSR (1), WHO/NIH/private foundations (1).

For the fifty-one faculty with at least a million dollars in external grant support, their high grant totals was not matched on average by their publication productivity. These faculty averaged 1.5 publications per faculty member per year, the vast majority (97%) of which were research publications rather than textbooks, encyclopedia entries, or publications in education. For all 2,980 faculty in the survey, whose average grant support was only a quarter of those to whom they are compared, the average number of peer-reviewed publications was 0.6 of which 90% were research publications. For the million-dollar faculty, only 21% of their publications included undergraduate coauthors compared to 26% for all faculty. Only 60% of the fifty-one faculty had 10 or more publications during the decade, and only half had any publication with an undergraduate coauthor. However, six of the fifty-

Frequency of Individual Research Awards. *The SourceBook* reported the frequency with which faculty in all predominantly undergraduate institutions received individual research awards from Research Corporation, ACS-PRF, NSF, and NIH for the period 1986–2000. The number of predominantly undergraduate institutions in the U.S. is approximately 1200, and fewer than 700 of them received one or more award during the survey period. The vast majority of these colleges and universities received two or fewer awards. These data suggest that few undergraduate institutions have the environment to maintain externally-funded, peer-reviewed research activities of their faculty. Listings of institutions having two or more awards from these funding sources can be found in *The SourceBook*.

Total Frequency of Research Corporation (CCSA), PRF (Type B), NSF (RUI Research) and NIH (AREA) Awards 1986 - 2000



one faculty had 10 or more publications with undergraduate coauthors, and this small faculty subset accounted for more than 60% of the student coauthored papers.

For faculty whose principal source of funding was the NSF, excluding those funded primarily for education-related activities, publication productivity for the decade was 19 per faculty member, ranging from 7 to 38, or nearly 2 per person per year. Faculty funded from NASA averaged 1.1 publication per faculty member per year, and the range was 0.4 to 2.3. From the NIH there was a bimodal distribution with two faculty reporting 23 and 39 publications, respectively, while four others had between 0 and 2 peer-reviewed publications during the decade.

Five faculty, three from biology and two from the geosciences, received their funding from state or local sources, mainly for surveys and environmental studies that were evaluated in the study as research. Several of these were a consequence of the existence of an institute or center at the institution with significant infrastructure devoted to such activities. Publications from two of the five, virtually all identified as research publications, numbered 40 and 60, respectively for the period 1990–2000, and one had 12 undergraduate student coauthors. The remaining three faculty had a total of 14 publications during the decade, and only one reported an undergraduate coauthor.

Five faculty, three as full professors and two as associate professors, received the majority of their funding for education and outreach, mainly from the NSF. A total of nearly $9M was reported by these faculty for the decade of the 1990s. Three faculty are in physics departments, with one each in chemistry and geoscience. These faculty reported 11 peer-reviewed publications for the decade, and none of them included undergraduate coauthors.

Thirty-publication faculty

Well, if million-dollar faculty do not provide a clear and consistent pattern of activity, perhaps 30-publication faculty could. We have surveyed the publication records of the nearly 3,000 faculty respondents for this information. Not included in these totals are "proceedings of a conference" or "transactions of a state academy of science" or newsletters, papers in press, or those outside of the time window of the survey. The criteria for inclusion would be those commonly agreed to be professional contributions that received external oversight. To have 30 peer-reviewed publications is five times above average, and there are only 38 such individuals among the 2,980 faculty who reported (1.2%). They represent 26 institutions, 17 that are private and nine public. Ten of the thirty-eight faculty are in Ph.D.-granting departments. Relevant characteristics of rank, gender, and discipline are given in Table 2.

The average number of publications per faculty member for the 1990s was 42, ranging from 30 to 78, and 98% of them were research publications; there was no difference here between faculty in Ph.D.-granting and non-Ph.D.-granting departments. However, only 19% of the reported publications included undergraduate coauthors. Fourteen of the thirty-eight faculty with 30 or more publications had at least 10 of their publications with undergraduate students, and an equal number of these faculty—only four of whom were in Ph.D.-granting departments—had no publications with undergraduates. There is an obvious disparity here with equal numbers of faculty involved and uninvolved in research with undergraduate students.

External funding for the 30-publication faculty averaged $830,811, with a range from no external funding to $2.8 million. The average of external funding for only those faculty in Ph.D.-granting departments was $888,750, not significantly different from the composite group.

$500,000 and ten or more publications

Moving now to those faculty who had $500,000 in external grant support over the 10-year period and

Table 2. Rank, gender and discipline characteristics of the 38 thirty-publication faculty.

RANK	
Associate Professor	4
Full Professor	34
GENDER	
Female	1
Male	37
DISCIPLINE	
Astronomy	3
Biology	6
Chemistry	14
Physics	13
Environmental Science	1
Neuroscience	1

10 or more peer-reviewed publications, there were ninety-eight identified, mainly in biology departments (29), followed by chemists (27), physicists (24), then geoscientists (6), astronomers (5), neuroscientists (4), and environmental scientists (3). Of the ninety-eight, nineteen were women, and twenty were at the assistant professor or associate professor levels. These faculty published, on average, 2.3 peer-reviewed papers per faculty member per year—significantly greater than the corresponding average (1.5) for the "million-dollar faculty." The ninety-eight faculty included undergraduate students on 29% of their publications, which is a percentage that is above the average for all faculty surveyed. Still, among the ninety-eight faculty, the publications of thirty-three of them did not include any undergraduate coauthor, suggesting once again the difficulties in involving undergraduate students in research at predominantly undergraduate institutions. Those who had half or more of their publications with undergraduate coauthors numbered twenty-three.

The conclusions that might be drawn from this analysis are not what might have been first envisioned —that those with the most external grant dollars or those with the greatest numbers of publications had a distinct advantage in drawing students into science at predominantly undergraduate institutions. Indeed, few among the "million-dollar faculty" do so. In fact, it's a rare individual who chooses to conduct a significant research program that involves undergraduate students in meaningful ways.

—Michael P. Doyle

ACADEMIC EXCELLENCE

Results from a comprehensive study of the environment for research in the natural sciences at predominantly undergraduate colleges and universities have been published in *Academic Excellence: The SourceBook*—539 pages of data and opinions which constitute an important resource for defining the current status of the natural sciences at the 136 surveyed institutions and in the broader universe of undergraduate institutions. These schools have served as a national resource for a significant proportion of students who undertake professional careers in the sciences, and a primary reason cited for their output has been the research experiences of undergraduate students with faculty mentors.

However, prior to this study there was a growing perception that resources and productivity were declining. Concern over these perceived trends by five private foundations with interests in the natural sciences (Research Corporation, the M. J. Murdock Charitable Trust, the W. M. Keck Foundation, the Welch Foundation, and the Camille and Henry Dreyfus Foundation, Inc.) prompted the intensive data collection and analyses for *Academic Excellence: A Study of the Role of Research in the Natural Sciences at Undergraduate Institutions*.

Copies of *The SourceBook* are available from Research Corporation. Orders must be prepaid by check or money order; $50.00, includes priority rate postage.

Research Corporation
101 North Wilmot Road, Suite 250
Tucson, Arizona 85711
Tel: 520.571.1111 • Fax: 520.571.1119
awards@rescorp.org • www.rescorp.org
Carmen Vitello, Editor

Research Corporation
A foundation for the advancement of science

101 North Wilmot Road, Suite 250
Tucson, Arizona 85711

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